Northeastern University - Seattle

Khoury College of Computer Sciences

CS6200 Information Retrieval Fall 2019

Lecture 1: Introduction to Information Retrieval

Sep 9, 2019

Overview

- Definitions of Information Retrieval (IR)
- IR Systems
- Databases
- What makes IR Systems different
- (Web) Search Engines
- What makes Search Engines different
- Why is Search important

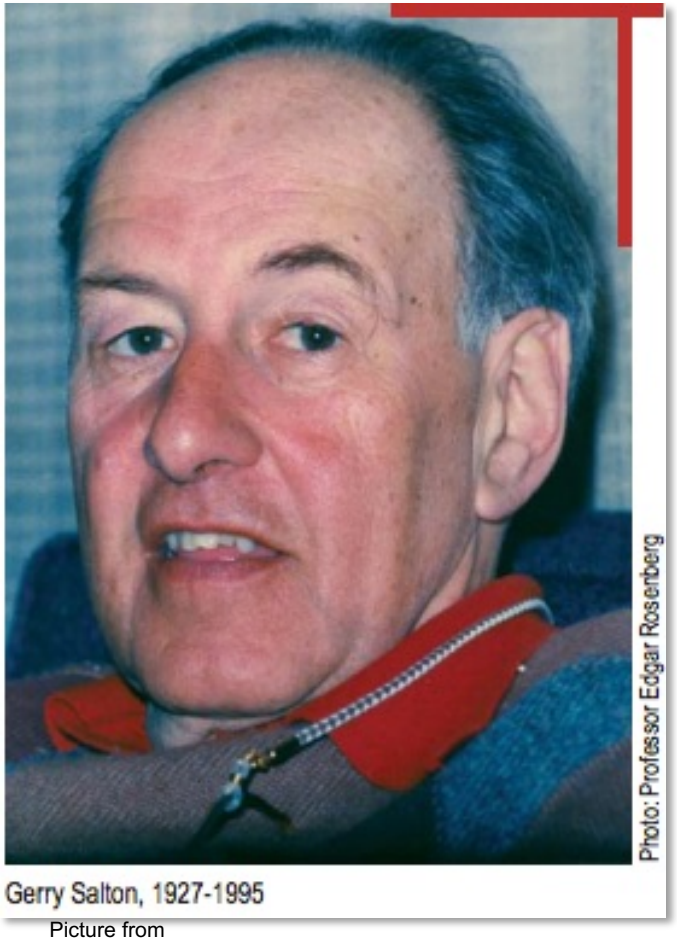
DEFINITIONS OF IR

Definitions of IR

"Information Retrieval (IR) is concerned with the representation, storage, organization, and accessing of information items"

Gerard Salton/

Michael McGill, 1983



Gerry Salton, 1927-1995

Picture from
http://www.cs.cornell.edu/gries/40brochure/pg24_25.pdf

Definitions of IR

"Information Retrieval (IR) is
finding material (usually documents),
of an unstructured nature (usually text)
that satisfies an information need
from within large collections
(usually stored on computers)"

Manning, Raghavan and Schütze, 2008

Digging into the Definition

- IR all around us
- Definitions intuitively clear
- But what are:
  - Documents? Nature of documents?
  - Information needs?
  - Collections?

- And how does IR compare with Database systems or Web search?

IR SYSTEMS

Documents & The Nature of Documents

Varying sizes: As small as a tweet, as big as a book, or even as huge as an encyclopedia

Various types: web pages, news stories, books, papers, blogs, IMs, tweets, Facebook posts, PDFs, Office documents, etc. etc.

May have definite structure:

mail messages (From/To/Subject);
papers (Authors, Affiliations, Where published…)
product details (as on shopping sites)

Typically content is (mostly) text, but may include images, audio and video clips etc.

Information Needs

A specification of information the user is looking for. Examples:

- "Picture of Gerard Salton"
- "Women's Singles winner in the US Open this year?"
- "What's a good vegetarian place we could go to, tonight?"
- "Next total solar eclipse and where I can see it"

Need to understand info need and retrieve appropriate information

Information needs get mapped to queries

Collections

Could be very general, e.g. web documents for Bing/Google/Baidu/Yandex etc. (“Internet”)

Could be specific to organizations (“Intranet”):

All NEU documents

All Microsoft documents

Could be domain-specific:

All scientific papers (DBLP, ArXiv etc.)

Could be small and specific:

Enron email corpus

DATABASES

Databases

Databases could be large but mostly ”about” a well-defined domain

Typically very structured

Usually clearly defined tables, records and relations

Examples:
Company and employee tables
Product info tables, with records for each product
…

Database queries & results …1

Typically very specific

E.g. “Find employees with salary > $100k in Seattle”

Easy to understand query

Semantics of query language usually unambiguous
Typically only one way to interpret query

Results usually very clear

Because query is clear, results equally clear

Database queries & results …2

Ordering of results usually well-defined
(or not important)

Usually specified, or standard default, e.g. "Find employees with salary > $100k in Seattle order by lastname asc"

Usually all matching records required

Evaluation of results usually simple

WHAT MAKES IR DIFFERENT

What makes IR different?
Not just text

Dealing not just with numbers/text, but with:

- Images
- Audio
- Video
- Mail messages
- ...

Query interpretation much more than exact matches on text, or numeric comparisons

What makes IR different? Specificity

Queries may be very vague:

- E.g. “North Korea missiles”
  What does the user expect?

Boolean queries may help a bit

- E.g. “North Korea” AND “missiles” NOT … OR …
- But hard to construct, and still not enough.
  Is one mention of
  “North Korea” and “missiles” enough to make it ”relevant”?
  That is, a good result? ➔ Leads us to “Aboutness”

What makes IR different? "Aboutness"

User's query could be hard to interpret:

Many ways to say the same thing
"Who won the US Open Women's Finals?",
"Who is the US Open Women's Finals winner?"

The same word could mean different things:
"Tesla", "Jaguars" vs. "Jaguar", …

Does one mention of "Northeastern"
make it "about" Northeastern things? NEU?

Hard to choose results, and order of results

"Aboutness" related to context and relevance

What makes IR different? Context

- Unlike with databases, **context** is important
  - You and I know different things and expect different results based on our understanding
  - We expect different results based on our location, previous queries etc.
    For example:
    "Pizza place"
    "income tax office"

    ➔ Evaluation of search is user-centric

What makes IR different? Relevance

Results have to be "relevant"

A relevant result document is one that the "user perceives as containing information of value with respect to their personal information need" [MKS].

Users typically want results in order of relevance.

Results and their ranking not computed on a complete "understanding" of the document collection and users' queries, but based on retrieval models

e.g. vector space model, probabilistic model etc.

What makes IR different? Evaluation

- Unlike databases, evaluation of results is non-trivial
  - Many methods to compare search engine results with users' notion of relevant results and result order
    - Users' expectations may even change with time
  - Some methods based on test collections and gold standards
  - Others based on side-by-side (Alpha-Beta) comparisons
  - Many metrics of the goodness (or effectiveness) of retrieval
    - including Precision, Recall, MAP, MRR, DCG, NDCG etc.

SEARCH ENGINES AND HOW THEY ARE DIFFERENT

Search Engines

Search engines: IR techniques applied to very large document collections

- Web Search engines: Search engines on web-scale document collections
- Many varieties, based on domain or application

Includes:

- Web search engines: Bing, Google, Yandex, Baidu etc.
- Open source engines: Lucene/Solr, ElasticSearch etc.
- Academic search engines: Lemur, Indri, Terrier etc.
- …

What makes (Web) Search Engines different?


Like all big systems, performance and scalability


Dealing with changing data


Different retrieval techniques for different domains


Issues with large-scale Spam and Duplicates and ranking issues


The need to provide a great user experience


Special issues because web search engines are ‘free’

Search Engines: Performance

Performance important, to keep and grow user base

Users have high expectations

- Need to be fast, keep response time low

Behind the scene efficiency requirements:

- Process documents and index them faster
- High query throughput, to handle more users/queries
- High accuracy, precision, recall etc.
- Fast spelling correction, fast rendering, fast suggestions, fast federation etc.

Search Engines: Scalability

As the collection size grows larger, and
as the number of simultaneous users grows bigger,

- Need to keep up, be as accurate and performant

Handling more data and more users:

- More systems? More memory etc.? Better hardware?
- Improved processes?
- Different architecture: e.g. more distributed systems?
- Improved software architecture?

Search Engines: Keeping up with data

Data collections keep growing at an impressive rate

- Especially Social media data (Twitter, Facebook, Weibo…)

Not all data updated frequently, or at the same rate

But users expect

- Coverage: more documents to be indexed and served
- Freshness: latest versions of documents

Need to get data as often as it is refreshed

Need to index and update running systems

Search Engines: Different domains

Different domains need different strategies and techniques for data acquisition, indexing, retrieval, presentation…

Consider web documents vs. news vs. product search vs. image or video search

Need to handle all this with a consistent UI/UX

Search Engines: Spam/Duplicates

- The web has loads of
  - Duplicate documents
    - E.g. GNU License document
  - Spam
    - Could come from SEO tools (term or link spam)
- Need to identify and deal with duplicates and spam, to improve performance and efficiency

Search Engines: User Experience

Need to give users a great search experience

- To impress and help users
- To keep users from going to other engines

Need to balance features against cost

Search Engines: “Free” search

Need to cover costs

- Need for ads, sponsored sites etc.

Again, need to consider user experience

- Good ads can complement web results
- But too many ads may chase away users

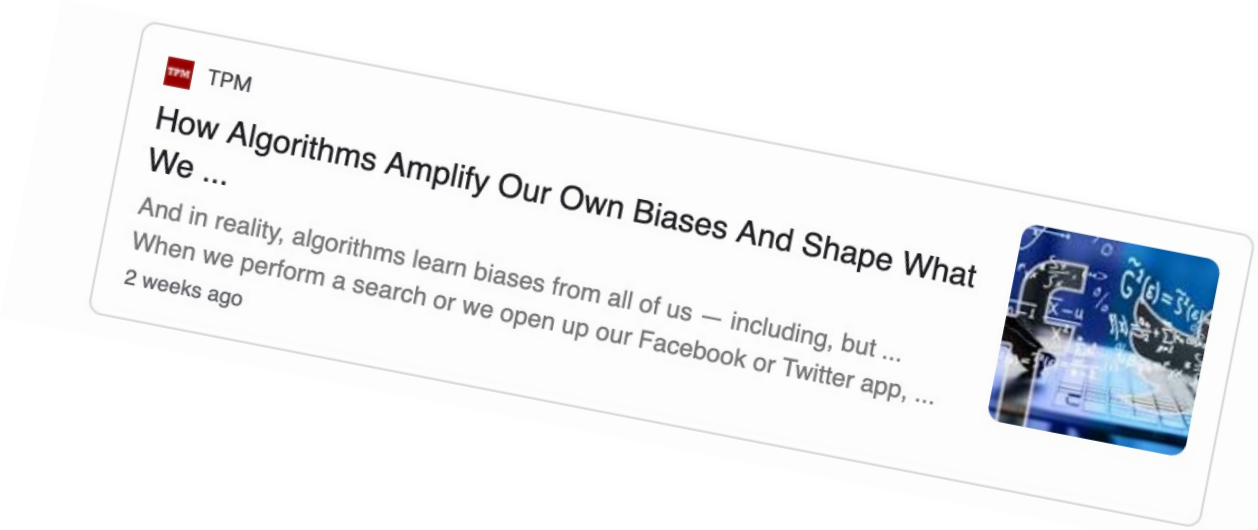
Our Focus

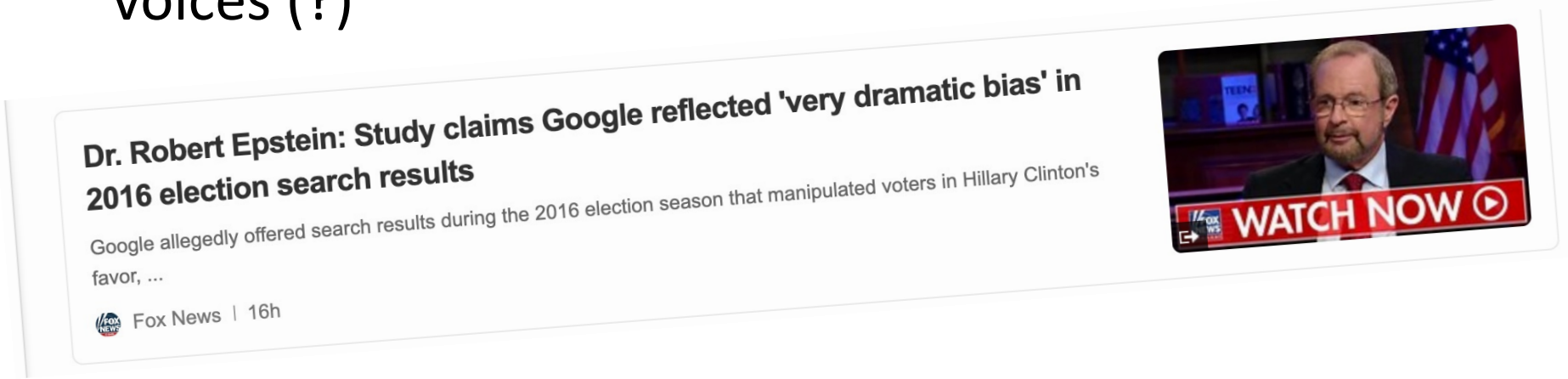
- We will focus on (Web) Search Engines, and:
  - Study individual search engine components, and techniques and alternatives used in these
  - Emphasize architectures and techniques used in real search engines
  - Provide pointers to follow up on other approaches

WHY IS SEARCH IMPORTANT

Why is Web Search so important? .. 1

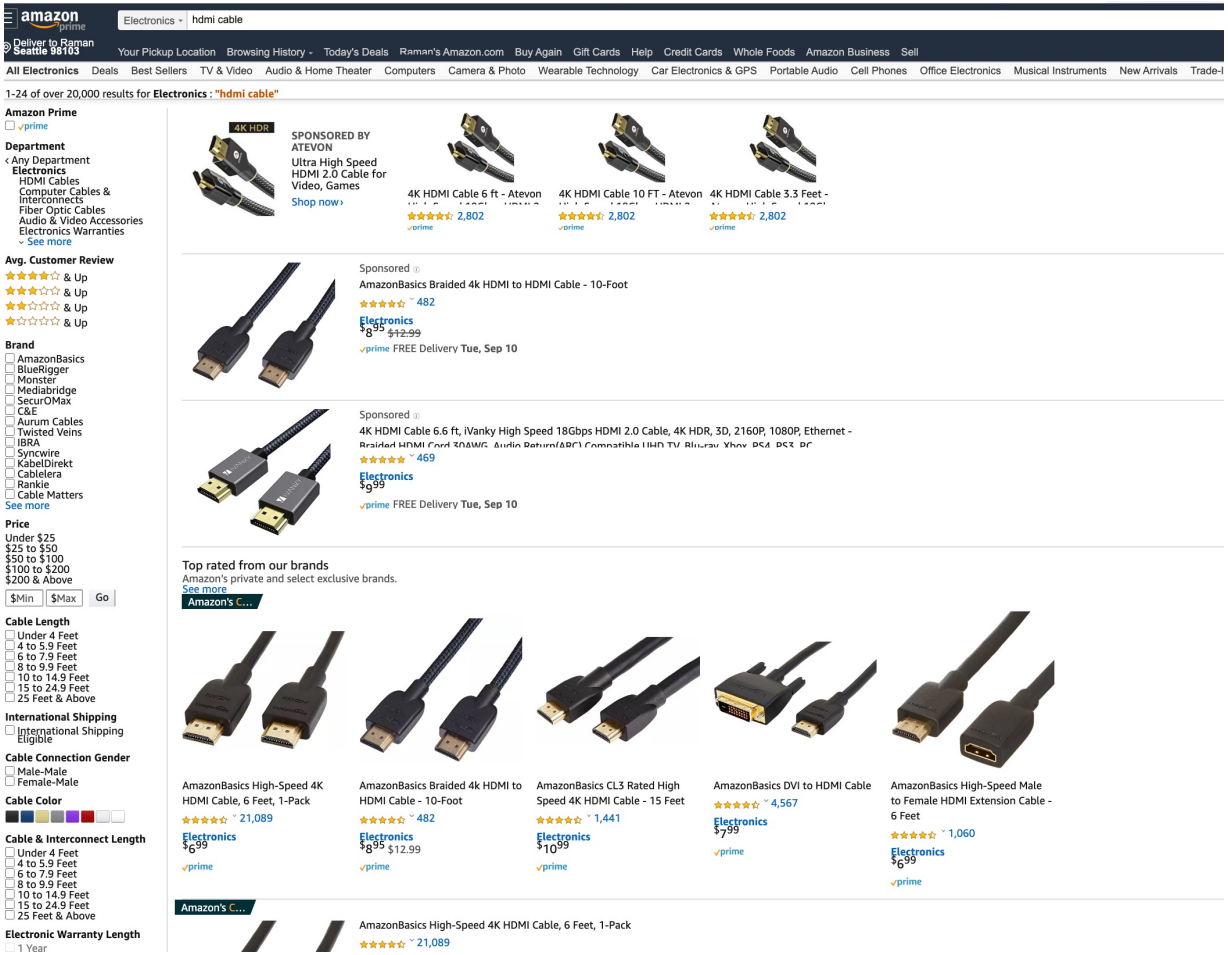
- Results can show bias in civic discourse
- Should offer access to all voices (?)





Why is Web Search so important? .. 2

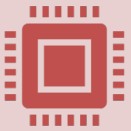
Marketing ‘bias’



Why is Web Search so important? .. 3

Search is how we navigate through the world

Definitions
Translations
News
Directions …



Complex software, involving big data, machine learning, text analysis, ranking, operations:
a big exercise in software project management

Affects everything.
Important to study it & get it **right**

Summary

- We've defined Information Retrieval (IR) and IR systems
- We've seen how they're different from Databases
- We've then seen how Search Engines differ from generic IR systems

- We've defined our focus: (Web) Search Engines, components, architecture and techniques
- Next: we look at ***Search Engine Architecture***

Readings

- Chapter 1 of CMS

- Recent news articles (just a sample):
  - https://www.foxnews.com/media/google-bias-search-results-trump-clinton-epstein-levin
  - https://psychcentral.com/blog/dr-epstein-political-bias-google-search-results/

Questions?